**Educational Administration: Theory and Practice**
2024, 30(4), 10873- 10880
ISSN: 2148-2403
https://kuey.net/
**Research Article**

# Effect Of Occupational Therapy Intervention Include Sensory-Motor and Proprioception Training on Older Adult with Diabetic Neuropathy: A Randomized Control Trial

Nitin Kumar Gautam[1*], Dr. Ankita Sharma[2], Dr. Shivani Bhardwaj[3], Prof. (Dr.) R.K Sharma[4]

[1]Master of occupational therapy (Neurology) Student, Santosh College of Occupational Therapy,
[2]Assistant Professor, Santosh College of Occupational Therapy, Ghaziabad,
[3]Assistant Professor (Occupational Therapy) Department of Occupational Therapy, School of Nursing Sciences & Allied Health, Jamia Hamdard, New Delhi,
[4]Dean, Paramedical and Principal, Santosh College of Occupational Therapy

***Citation:*** Nitin Kumar Gautam, et. al (2024), Effect of Occupational Therapy Intervention Include Sensory-Motor and Proprioception Training On Older Adult With Diabetic Neuropathy: A Randomized Controlled Trial, *Educational Administration: Theory and Practice, 30(4)* 10873- 10880
*Doi:* 10.53555/kuey.v30i4.8782

**ARTICLE INFO**

**ABSTRACT**

**Background:** Diabetes mellitus frequently results in diabetic neuropathy, a condition marked by nerve degeneration that impairs sensation and movement. Diabetic Neuropathy causes disorders, and has a major impact on movement, balance, and general quality of life, and especially common among elderly persons. People have sensory deficiencies and reduced proprioception, which increase their risk of falling and restrict their functional independence.
**Study design:** A Randomized Control Trial
**Aim:** To investigate the Effect of Occupational Therapy intervention, which includes Sensory-Motor & Proprioception Training on Older Adult with Diabetic Neuropathy.
**Objective:** To Evaluate the Pre and post effect of Occupational Therapy intervention, including Sensory-Motor & Proprioception Training on Older Adult with Diabetic Neuropathy through Functional Reach Test, Timed-up and Go Test, and Nottingham Sensory Assessment.
**Participants**: The participants were recruited based on exclusion and inclusion criteria. A total of 32 participants were included in the study.
**Methods: -** This is randomized control study; a total 32 participants were included with Diabetic Neuropathy. Participants were randomly assigned in one of 2 groups: control group with usual Diabetic foot care education and walking and experimental group with sensory-motor and proprioceptive training. Exercise intervention was conducted in 3 sessions per week for 8 weeks. The outcomes of the intervention were assessed using FRT, TUG, OLS and NSA outcome measure.
**Result:** In Functional Reach Test (FRT) with mean (14.188) and ($p<0.001$) resulted an improvement in Dynamic Balance and stability. In Timed-up and Go Test (TUG) with mean (10.313) ($p<0.001$) indicates an improvement in functional mobility and Balance. In One Leg Stance Test, Eye open with mean (33.688) ($p<0.05$) and eye closed with mean (7.938) ($p<0.05$) resulted an improvement in Static Balance whereas Nottingham Sensory Assessment (NSA) with mean score (11.187) for upper limb and (7.75) for lower limb with ($p<0.001$) results an improvement in proprioception in both U/L and L/L in which U/L indicate more improvement.
**Conclusion:** This study demonstrates the effect of Sensory-motor and proprioception Training is more significant than the conventional group Training which include Foot care and walking For Balance (Static and Dynamic), Functional Mobility and Proprioception abilities of Diabetic Patients. This Training helps Diabetic patients to improve Balance, Functional mobility and proprioception.

**Keywords:** FRT, TUG, Proprioception, DPN, Diabetic Neuropathy, Balance, Functional Mobility, OLS, T1DM, T2DM, NSA.

*Copyright © 2024 by Author/s and Licensed by Kuey. This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

## INTRODUCTION:

Diabetes occurs when the pancreas produces insufficient insulin or when the body's cells lose sensitivity to the hormone's effects. Hyperglycemia and altered lipid metabolism are hallmarks of diabetes mellitus (DM), a metabolic disease that can be identified by metabolomics.[1]

According to WHO, a majority of the 422 million Diabetes affects people in low- and middle-income countries worldwide, and it is directly responsible for 1.5 million deaths per year. Over the past few decades, there has been a steady increase in both the number of cases and the incidence of diabetes.[2] The International Diabetes Federation reports that there were 537 million diabetic patients globally in 2021; by 2045, that figure is expected to rise to 783 million.[3]

Diabetes mellitus (DM) is a metabolic condition characterized by abnormally high blood glucose levels. There are several forms of diabetes mellitus, including type 1 and type 2 diabetes, gestational diabetes, neonatal diabetes, maturity-onset diabetes of the young (MODY), and Secondary causes of endocrinopathies, steroid usage, etc. The two most common forms of the disease are type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM). One of the most prevalent conditions linked to both type 1 and 2 diabetes is diabetic neuropathy (DN). Neuropathy is a nerve injury that starts proximally and spreads to the longest nerves in the toes. [4]

DN is a widespread condition that drastically reduces patients' quality of life, increases their risk of falling, and causes discomfort. While diabetes is widely acknowledged as the primary the metabolic warning signs for neuropathy, managing hyperglycemia on its own is not enough to shield those with type 2 diabetes from developing neuropathy.[5]

The symptoms of diabetic peripheral neuropathy (DPN), a gradual degeneration of the peripheral nerves that compromises their autonomic, sensory and motor components, include loss of protective sensation, foot anhydrosis and intrinsic foot muscle dysfunction. With the correct care, the disease's most deadly consequence—plantar ulceration and amputation—can still be prevented. DPN patients have shorter strides, longer stance times, lower cadences, more step variability, and decreased gait velocity when compared to healthy controls. Walking on uneven surfaces makes these gait variances more apparent.[6]

DPN is particularly prevalent in middle-aged people (40–60 years) and older adults (60+ years) who have sensory loss in areas such joint position, pressure, vibration perception, and discomfort, which reduces control over balance and gait coordination.[7]

The most typical symptoms of DPN include tingling, discomfort, numbness, and weakness in the hands and feet, though it can cause a wide range of incapacities and comorbidities. [8]

Furthermore, the body's immune system and immunological function are harmed by the confluence of hyperglycemia and metabolic problems. As a result, this subtle, unseen wound may eventually become infected and cause significant limb damage. In high-income countries, DPN is the primary cause of non-traumatic lower limb amputations.[9]

Peripheral neuropathy typically causes combining sensory neuropathy (impairment of protective input), motor neuropathy, and autonomic neuropathy. The anatomy and function of the foot are impacted by each of these anomalies associated with peripheral neuropathy. Decreased ROM, the development and worsening of foot abnormalities, weakening and compromised distal muscle function, and modifications to the way the foot rolls over while engaging in locomotor activities are a few examples.[10]

Patients with DPN have an inverse relationship between the quantity of intramuscular adipose tissue and the number of steps they take, indicating that a lack of physical activity is the primary cause of muscular weakness. Gait speed is drastically reduced by motor & sensory impairments & restricted foot motion, which negatively impacts quality of life.[11]

DN might make it difficult to balance when performing daily chores. Five times as many falls occur in people with DN, increasing the risk of mobility loss, activity avoidance, institutionalization, and even mortality. [12]

In DPN, postural instability and imbalance are frequently observed. While a decrease of motor axon activity results in muscular weakness, a lack in sensory neuron functions result in low sensory sensation from limbs. Deficits in proprioception & alterations in motor neuron result in imbalance and insufficient muscular contraction. Balance and gait are produced by intricate brain and muscle mechanisms that are synchronized with musculoskeletal activities. [13]

The ability to coordinate complicated balance and postural control, as well as basic defensive reflexes and joint movement, declines with a loss in proprioception. Balance impairments are caused by unequal weight bearing due to decreased proprioception, delayed reflex reactions to abrupt changes in posture, and muscle weakening, especially in the elderly. The main reason why older people die young is falls brought on by unsteady gait and poor balance.[14]

Damage to these nerves, as in DPN, can result in incomplete or wrong messages to the brain, making it harder to coordinate movements and correct posture, which raises the risk of falls. Additionally compromising the stability, the loss of foot sensation might make it difficult to recognize difficulties or changes in the texture of the ground. Finally, poor balance control, tripping, and unsteadiness are possible symptoms of DPN.[15]

Maintaining stability requires strong, flexible, and coordinated muscles, all of which can be improved with exercise. Additionally, by improving blood circulation and helping to control blood sugar levels, it can help halt the onset of neuropathy and give vital nutrients and oxygen to peripheral nerves.[16]

So, Due to their impaired sense of balance and proprioception, people with DPN may be more likely to fall. Balance and gait are governed by intricate relationships between skeletal and neuromuscular activity. Impaired function resulting from diminished balance can negatively impact a quality of life of a patient. Aerobic Exercise can help DPN patients suffering with all of these issues. Therefore, this study will evaluate the sensory-motor difficulties in DPN patients and offer them the proper proprioception and sensory-motor training.

## METHODOLOGY:

A total of 32 participants included in the study through Random sampling and divided into 2 groups experimental and control group. In experimental group, occupational therapy intervention including sensory-motor and proprioception training was provided to the individuals for duration of 8 weeks, three times per week (Table 1). In controlled group, Foot care education and walking was provided to the participants for duration of 8 weeks, three times a week (Table 2). Participants were recruited from SANTOSH HOSPITAL, Ghaziabad as per inclusion criteria patients who having Age range should be 60 - 75 years, both male and female, and individuals who can walk independently was included and as per exclusion criteria patients who are having other neurological condition, having any physical disability, patients who uses wheelchair, having any ulcer or any infection on foot, or having any musculoskeletal condition were excluded. Participants were given an informed consent form outlining the goals and methods of the study prior to its commencement. They were given sufficient time, as well as an explanation about the study, to go over the document and ask any questions before giving their written agreement.

**Table 1: - Experimental Group**

| **Proprioception Training** | | | | |
|---|---|---|---|---|
| **S.no.** | **Name of the activity** | **Procedure** | **Purpose** | **Duration/ Repetition** |
| 1. | Warm up | 1. Standing with hands resting on the side, open and close the side with the breaths. | Proprioception training | 1 set for 2 minutes |
| | | 2. Standing with hands on the iliac crests, mobilization of the pelvis in anterior and retroversion with breaths. | Proprioception training | 1 set for 2 minutes |
| | | 3. Prone decubitus: cat stretch. | Proprioception training | 1 set for 2 minutes |
| | | 4. Bird dog | Proprioception training | 1 set for 2 minutes |
| 2. | Central phase | Circuit | | |
| | | - Balance on one leg (stork position).<br>- Get up from a 60cm High chair<br>- Walking on a proprioceptive pad<br>- Walk in a straight line of 10 meters.<br>- Throw softballs towards a wall 10 feet away | Proprioception training | 3 set 10 per leg<br>3 set 5 repetitions<br>3 set 10 per leg<br>3 set<br><br>3 set 10 times |
| 3. | Cool down | 1. Walking | Proprioception training | 1 set for 5 minutes |
| | | 2. Supine Decubitus (breathing with the perception of every part of the body) | Proprioception training | 1 set for 5 minutes |
| | | 3. Stretching | Proprioception training | 1 set for 5 minutes |
| **Sensory Motor Training: -** | | | | |
| 1. | Warm up | Ergonomic Cycle | Sensory-motor training | 10 min |
| 2. | exercise | -Wall Slide<br>-Core Exercise<br>-Balance Exercise on unstable Surface<br>-Gait training | Sensory-motor training | 50-60 min |

| | | | | |
|---|---|---|---|---|
| 3. | Cool down | 1. Deep Breathing<br>2. Abdominal Breathing<br>3. Mild Stretching | Sensory-motor training | 5 -10 min |

**Table 2: - Conventional Group**

| S.no. | Name of the activity | Procedure | Duration/ Repetition |
|---|---|---|---|
| 1. | Diabetic Foot care | Educate about the complications of diabetes, diabetes management, and foot care guidelines, along with dietary counselling | 30 min |
| 2. | Walking and Jogging | Walking/ Jogging in Park | Daily |

**Outcome measures:**

**Functional Reach Test (FRT)** - FRT was used to measure dynamic balance by measuring the subject's maximal forward reach beyond the length of one's own arm while keeping a fixed base of support in the standing position. Each subject was directed to stand beside the wall with feet shoulder apart and arms extended as far as possible. The distance of moving the knuckle's end was measured (in cm) without taking a step forward or contacting the wall, using measuring tape. FRT is a precise, valid, and reliable metric with a known sensitivity to change.[17]

**Timed Up & Go Test (TUG)** - TUG is a commonly utilised and reliable test for assessing functional mobility in frail older individuals living in the community. It measures the time (in sec) required to stand up from a normal armchair, walk 3 metres, turn, return to the chair, and sit down. The time required to complete TUG is substantially correlated with the danger of falling. Healthy adults who do this test in fewer than 10 seconds have a lower chance of falling. [18,19]

**One Leg Stance (OLS)-** OLS is a widely used assessment of static balance abilities with high reliability in community-dwelling older individuals. Each subject conducted the test with their dominant leg first, followed by the other leg, under two conditions: eyes open (90 sec) and eyes closed (60 sec). They were instructed to stand on one leg, hands on the waist, and lift the other leg to the level of the shin. The time (in sec) was recorded using a stopwatch until the standing foot changed or the lifted foot hit the ground.[20]

**Nottingham Sensory Assessment for Kinaesthetic Sensation-** All three characteristics of movement are measured concurrently: enjoyment of movement, direction, and correct joint position awareness. The examiner supports and moves the limb on the affected side of the body in various directions, but only one joint at a time. The patient is instructed to mirror the shift in movement with the other limb. Three practice motions are permitted prior to blindfolding. Correlation coefficients were good to exceptional between the rNSA and the FMA-S. The rNSA proprioception measure predicted the FMA-S. [21]

**Data analysis:** The scoring of evaluated data of outcome measure FRT, TUG, OLS and NSA were analysed using IBM SPSS VERSION v26.0 for statistical significance result. The mean and standard deviation of the various FRT, TUG, OLS, and NSA variables were analysed using a paired T-test.

## RESULT: Descriptive Statistics of outcome measure: -

**Table 3: t-test for pre-test and post-test of FRT (Balance) in control and experimental group.**

| Test | Group | Means | Standard deviation | St. Error mean | p-value |
|---|---|---|---|---|---|
| Pre | Experimental | 8.313 | 2.522 | 0.631 | <0.001 |
| | Control | 8.75 | 2.408 | 0.602 | |
| Post | Experimental | 14.188 | 1.905 | 0.476 | <0.001 |
| | Control | 8.75 | 2.408 | 0.602 | |

Table 3 shows the scoring of functional Reach Test (FRT) shows a substantial improvement with means value increasing from 8.31 (PRE) to 14.19 (POST) with a high significant p-value of 4.7×10−104.7 \times 10^ {-10}4.7×10−10, indicating enhanced Balance and Stability.

**Table 4: t-test for pre-test and post-test of TUG (Balance) in control and experimental group.**

| Test | Group | Means | Standard deviation | St. Error mean | p-value |
|---|---|---|---|---|---|
| Pre | Experimental | 18.438 | 2.92 | 0.73 | <0.001 |
| | Control | 18.437 | 2.22 | 0.555 | |
| Post | Experimental | 10.313 | 2.358 | 0.59 | <0.001 |
| | Control | 18.437 | 2.22 | 0.555 | |

Table 4 shows the scoring of TUG reveals a significant reduction in time from 18.44 second (PRE) to 10.31 seconds (POST), reflecting improved Mobility and balance with a significant low p- value (5.28×10−85.28 \times 10^ {-8}5.28×10−8).

**Table 5: - t-test for pre-test and post-test of OLS (Balance) in control and experimental group.**

| Test | Group | Means | Standard deviation | St. Error mean | p-value |
|---|---|---|---|---|---|
| Pre (EO) | Experimental | 15.125 | 6.582 | 1.645 | <0.05 |
| | Control | 12.125 | 5.795 | 1.449 | |
| Post (EO) | Experimental | 33.688 | 5.839 | 1.460 | <0.05 |
| | Control | 14.25 | 6.181 | 1.545 | |
| Pre (EC) | Experimental | 3.188 | 1.328 | 0.332 | <0.05 |
| | Control | 3.375 | 1.204 | 0.301 | |
| Post (EC) | Experimental | 7.938 | 2.351 | 0.588 | <0.05 |
| | Control | 3.875 | 1.408 | 0.352 | |

Tabel 5 shows the OLS test for balance with a marked progress, particularly with eye open with means value increased from 15.13 second to 33.69 seconds with a significant p-value (3.05×10−103.05 \times 10^{-10}3.05×10−10) and eye closed with a means value increased from 3.19 seconds to 7.94 seconds with a p-value of 7.79×10−97.79 \times 10^{-9}7.79×10−9, underscoring an enhanced balance and proprioception control.

**Table 6: - t-test for pre-test and post-test of NSA (proprioception) in control and experimental group for upper limb.**

| Test | Group | Means | Standard deviation | St. Error mean | p-value |
|---|---|---|---|---|---|
| Pre | Experimental | 7.875 | 1.7842 | 0.446 | <0.001 |
| | Control | 6.938 | 1.18 | 0.30 | |
| Post | Experimental | 11.1875 | 1.0468 | 0.2617 | <0.001 |
| | Control | 6.938 | 1.18 | 0.30 | |

**Table 7: - t-test for pre-test and post-test of NSA (proprioception) in control and experimental group for lower limb.**

| Test | Group | Means | Standard deviation | St. Error mean | p-value |
|---|---|---|---|---|---|
| Pre | Experimental | 4.25 | 0.9309 | 0.2327 | <0.001 |
| | Control | 3.875 | 0.50 | 0.13 | |
| Post | Experimental | 7.75 | 0.8563 | 0.2327 | <0.001 |
| | Control | 3.938 | 0.57 | 0.14 | |

The above table 6 and 7 shows the paired t-test compares the pre- and post-intervention scores for both control and experimental groups in terms of the Nottingham Sensory Assessment (NSA) for upper and lower limbs.
In the control group, the mean scores remain unchanged for the upper limb (6.9375 pre and post) and show a negligible increase for the lower limb (from 3.875 to 3.9375). Moreover, the p-value (P(T<=t) two-tail) for the lower limb (0.33317) is greater than the standard significance level (0.05), indicating that the difference in scores is not statistically significant. Conversely, the experimental group demonstrates notable improvements. The mean upper limb scores increase from 7.875 to 11.1875, and the lower limb scores improve from 4.25 to 7.75. These changes are associated with lower variance post-intervention, suggesting consistent improvement among participants. The extremely small p-values (2.31E-08 and 3.7E-14 for upper and lower limbs, respectively) are far below 0.05, indicating that these improvements are statistically significant.
Overall, the experimental group shows substantial improvement in sensory assessment scores compared to the control group, making it the more effective approach. This is evident from the significant increases in means

and statistically significant p-values, highlighting the experimental intervention's success in enhancing sensory function.

## DISSCUSSION:

The primary aim of this study was to investigate the effects of sensory-motor and proprioceptive training on diabetic patients with diabetic neuropathy, particularly those experiencing balance impairments and reduced proprioceptive input. This population faces an elevated risk of falls, highlighting the importance of determining the most effective interventions to enhance balance and minimize fall risk. The data was analysed using t-test, calculating mean, standard deviation, and p-value. Results demonstrated that sensory-motor and proprioception training program was significantly effective, with the experimental group showing much better balance (both static and dynamic), functional mobility, and proprioception compared to the control group. The study emphasises how targeted training may help individuals with DPN improve their proprioception, functional mobility, and balance.

Dynamic balance was assessed using the FRT, static balance using the OLS test, proprioception through the Nottingham Sensory Assessment, and functional mobility using the Timed-Up and Go (TUG) test. Evaluations was carried out before and after the intervention to identify any significant changes in these outcomes. In contrast to the above-mentioned results, Kavita and Subramaniam in their study on functional status in individuals with DPN concluded that improvement in the TUG test was notably achieved through home-based strength and balance training.[22] On the other hand, Irshad at. al. in his study on DPN patients concluded that sensorimotor and gait training are effective in enhancing proprioception, nerve function, and muscular activation.[23] In another study, Kavinda at. al. in his study on patient with diabetic polyneuropathy concluded that there is no significant change in proprioceptive deficits was observed after six weeks but showed notable improvement at twelve weeks from proprioceptive rehabilitation program. [24]

## CONCLUSION:

This study demonstrates that occupational therapy interventions combining sensory-motor and proprioception training improves balance, mobility, and sensory function in older persons with diabetic neuropathy. The significant enhancements in functional and sensory metrics, such as the FRT, TUG, OLS, and NSA scores, underscore the intervention's potential to address the challenges of impaired mobility and balance in this vulnerable population. The statistical analysis highlights the significant improvement in Balance, functional mobility and proprioception in the experimental group compared to controlled group. These improvements suggest the effectiveness of the interference in enhancing the Balance, functional mobility and proprioception. The intervention led to significant positive changes in the experimental group, underscoring its potential benefits

## LIMITATION OF THE STUDY:

1. The study is limited to only proprioception while the tactile and stereognosis in NSA assessment can also be taken into the account to draw more inferences.

## FUTURE RECOMMENDATION:

The future recommendations are as follows:

1. Future studies need to include the tactile and stereognosis in the NSA assessment.
2. Future research established with larger sample size, which would Improve the power of statistical analysis and also increases the generalizability of the result.
3. The intervention program may be modified for the application of tactile and stereognosis dysfunction.
4. Further study could explore the long-term effect of such intervention and identify optimal strategies for sustaining balance, functional mobility and proprioception gain over time.

## ACKNOWLEDMENT:

I express my gratitude to the following individuals for their assistance and involvement in this project: Dr. P. Mahalingam, Chairman and Vice Chairman of Santosh Medical College, Santosh College of Occupational Therapy, Ghaziabad; Prof. (Dr.) R. K. Sharma, Dean, Paramedical & Principal of occupational therapy college; Dr. Ankita Sharma, Assistant Professor and the subjects who participated in the study. Thank you also to my parents and God for their blessings. These people provided direction and encouragement, which made the endeavour possible.

## REFERENCES:

1. *Shoback DG, Gardner D, Greenspan's basic& clinical endocrinology (9th edition) (2011).*
2. *Diabetes, World Health Organisation (2023).*
3. *International Diabetes Federation. Annual Report 2021. International Diabetes Federation; Brussels, Belgium: 2021.*

4. *Rajaei E, Jalali MT, Shahrabi S, Asnafi AA, Pezeshki SMS. HLAs in Autoimmune Diseases: Dependable Diagnostic Biomarkers? Curr Rheumatol Rev. 2019;15(4):269-276.*
5. *S.Ashok Krishnan, Inaganti Voliva* , K.Sridevi, A Mini-Review On Diabetic Neuropathy Volume.7, Issue.4, July-August (2022).*
6. *Kavita Venkataraman, Bee Choo Tai, Eric Y.H. Khoo, Subramaniam Tavintharan, Kurumbian Chandran, Short-term strength & balance training does not improve quality of life but improves functional status in individuals with diabetic peripheral neuropathy: a randomized controlled trial. (2019) 62:2200-2210.*
7. *Irshad Ahmad, Majumi M. Noohu, Shalini Verma, Deepika Singla & Mohd Ejaz Hussain, Effect of sensorimotor training on balance measures & proprioception among middle & older age adults with diabetic peripheral neuropathy. (2018) Gait & Posture 114-120.*
8. *Cristina Dallemole Sartor, Ricky Watari, Anice Campos Pássaro, Andreja Paley Picon, Renata Haydée Hasue & Isabel CN Sacco, Effects of a combined strengthening, stretching & functional training program versus usual-care on gait biomechanics & foot function for diabetic neuropathy: a randomized controlled trial. (2012) BMC Musculoskeletal Disorder.*
9. *Jinxi Zhu, Zihan Hu, Yifan Luo,and Jialing Hu, Diabetic Peripheral Neuropathy: pathogenetic mechanisms and treatment. (2024) Front Endocrinol.*
10. *Jaap J. Van Netten, Isabel C.N. Sacco, Lawrence Lavery and Joanne Paton, Clinical and biomechanical effectiveness of foot-ankle exercise programs and weight-bearing activity in people with diabetes and neuropathy: A systematic review and meta-analysis. (2023) Metabolism Research and Reviews, Vol 40, Issue 3.*
11. *Renan L. Monteiro, Cristina D. Sartor, Jane S. S. P. Ferreira, Milla G. B. Dantas, Sicco A. Bus & Isabel C. N. Sacco, Protocol for evaluating the effects of a foot-ankle therapeutic exercise program on daily activity, foot-ankle functionality, & biomechanics in people with diabetic polyneuropathy: a randomized controlled trial. (2018) BMC Musculoskeletal Disorder.*
12. *Bogdan Timar, Romulus Timar, Laura Gaiță, Cristian Oancea, Codrina Levai and Diana Lungeanu, The Impact of Diabetic Neuropathy on Balance and on the Risk of Falls in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study (2016).*
13. *Narges Jahantigh Akbari1 and Sedigheh Sadat Naimi, The effect of exercise therapy on balance in patients with diabetic peripheral neuropathy: a systematic review. (2022) J Diabetes Metab Disord.*
14. *Chang Ho Song, Jerrold S. Petrofsky, Seung Won Lee, Kyoung Jin Lee., and Jong Eun Yim, Effects of an Exercise Program on Balance and Trunk Proprioception in Older Adults with Diabetic Neuropathies. (2011) Vol. 13 Diabetes Technology & Therapeutics.*
15. *Ettinger LR, Boucher A, Simonovich E. Patients with type 2 diabetes demonstrate proprioceptive deficit in the knee. World J Diabetes. 2018;9:59–65.*
16. *Singleton JR, Foster-Palmer S, Marcus RL. Exercise as Treatment for Neuropathy in the Setting of Diabetes and Prediabetic Metabolic Syndrome:A Review of Animal Models and Human Trials. Curr Diabetes Rev. 2022.*
17. *Pamela W. Ducan, Debra K. Weiner, Julie Chandler & Stephanie Studenski, Functional reach: A New Clinical Measure of Balance. (1990) Journal of Gerontology, Vol. 45, Issue 6.*
18. *D. Podsiadlo, S. Richardson, The timed "up & go": a test of basic functional mobility for frail elderly persons, J. Am. Geriatr. Soc. 39 (2) (1991) 142–148.*
19. *R.W. Bohannon, K. Schaubert, Long-term reliability of the timed up-&-go test among community-dwelling elders, J. Phys. Ther. Sci. 17 (2) (2005) 93–96.*
20. *M. Lin, H. Hwang, M. Hu, H.I. Wu, Y. Wang, F. Huang, Psychometric comparisons of the timed up & go, one leg stand, functional reach, & Tinetti balance measures in community dwelling older people, J. Am. Geriatr. Soc. 52 (8) (2004) 1343–1348.*
21. *Ching-yi Wu, I-ching Chuang, Hui-ing Ma, Keh-chung Lin & Chia-ling Chen, Validity & Responsiveness of the Revised Nottingham Sensation Assessment for Outcome Evaluation in Stroke Rehabilitation. (2016) American journal of Occupational Therapy Vol. 70(2).*
22. *Kavita Venkataraman, Subramaniam Tavintharan, "Short-term strength and balance training does not improve quality of life but improves functional status in individuals with diabetic peripheral neuropathy: a randomised controlled trial."*
23. *Irshad Ahmed, Shalini Verma, "Sensorimotor and gait training improves proprioception, nerve function, and muscular activation in patients with diabetic peripheral neuropathy: a randomized control trial".*
24. *Kavinda T Malwanage, Esther Liyanage,"A novel proprioceptive rehabilitation program: A pilot randomized controlled trail as an approach to address proprioceptive deficits in patients with diabetic polyneuropathy"..*

**Table 8: -**

| **List Of Abbreviations** | |
|---|---|
| DPN- Diabetic peripheral Neuropathy | NSA- Nottingham Sensory Assessment |
| DM- Diabetic Mellitus | MODY- Maturity-onset Diabetes of the young |
| FRT- Functional Reach Test | T1DM- Type 1 Diabetes Mellitus |
| TUG- Timed Up & Go Test | T1DM- Type 2 Diabetes Mellitus |
| OLS- One Leg Stance | ROM- Range of Motion |